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UTILIZATION OF WASTE ORANGES

BY
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Orange Culls

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UTILIZATION OF WASTE ORANGES*

BY
W. V. CRUESS

SUMMARY

Orange Juice.—A very palatable and attractive beverage can be made from oranges. The chief difficulty is the mechanical one of rapidly and economically separating the juice from the solid parts of the fruit. The juice can easily be made perfectly and permanently clear by settling and filtration. Sulfurous acid in very small amounts is necessary to prevent fermentation and the production of a bitter taste during settling. The cleared juice keeps perfectly after bottling if pasteurized at 180° F., which does not injure the flavor perceptibly. Good oranges will yield over 130 gallons per ton. Frozen oranges less than half of this.

Orange Wine.—All the so-called orange wines examined were found to be mixtures and decoctions of inferior quality. A very agreeable pure orange wine can be made by the use of proper methods. These methods consist of defecation with sulfurous acid, fermentation with pure yeast and filtration. This wine can be made sparkling by a supplementary fermentation in the bottle.

Orange Vinegar.—From orange wine a fairly good vinegar can be made, but not equal to wine or cider vinegar. Unless careful and appropriate methods are used the vinegar is liable to be below legal strength.

A very large quantity of oranges is wasted every year in California. At the packing houses, any orange showing a defect in shape, color, or size, or a slight injury to the skin is rejected. The total amount wasted in this way is variously estimated at from 5 to 20 per cent of the total crop. In years when there is unusually cold weather it may be much greater.

There are various uses to which rejected oranges could be put, and a small number of them are now used in the manufacture of various citrus by-products. A collection of such by-products was obtained in the market and examined at the Zymological Laboratory.

* The experiments reported in this publication were undertaken at the suggestion of Professor F. T. Bioletti and the methods of investigation were outlined by him.

The collection consisted of various preserves, such as marmalades, dried and candied peel, bottled pulps and syrups; various alimentary liquids and beverages such as unfermented orange juice, orange wine and orange vinegar, and various chemical preparations, such as extracts, essential oils, citric acid and citrates. Many of the products were of good to fair quality, especially those which can be prepared by chemical or mechanical means. Others were bad, especially those the preparation of which involves some fermentation process.

Of the latter, three come within the scope of the work of the Zymological Laboratory, i.e., *Orange Juice, Orange Wine and Orange Vinegar.* Tests already made at the laboratory had shown that it was possible by simple means to produce and preserve a very attractive, palatable and nutritious juice from oranges. A further series of tests was undertaken to find the best practical methods of preparing this juice, and further to see whether wine and vinegar of commercial value could also be produced from "cull" oranges, especially from those injured by frost.

This bulletin gives the results of these tests. They demonstrate that it is possible to produce not only an orange juice that will keep, and retain the agreeable flavor of fresh oranges, but also a light, refreshing wine with pleasant acidity and fresh orange flavor. A fairly good vinegar of standard strength was also made, but not equal in quality to either wine or cider vinegar.

The chief difficulty in the way of manufacturing any of these products appears to be the mechanical one of separating the juice cheaply without spoiling it by mixing with the juices of the orange skin. If a machine could be devised to peel the orange economically, the remainder of the process would be simple.

ORANGE JUICE

Yields and Composition.—A number of tests of sound and of frozen oranges was made to determine the volume of juice which should be expected from a ton of fruit. The yields were obtained by crushing the pulp from weighed lots of oranges and pressing in a small meat press.

TABLE 1.—YIELDS OF JUICE

Sample	Juice per cent	Juice in gals. per ton
No. 715. Frozen Valencias	19.1	42.5
No. 717. Frozen Navels	20.2	45.0
No. 1110. Sound Valencias	55.3	132.8

The unfrozen oranges yielded not far from as much juice as can be extracted from grapes; the frozen oranges only about 25 to 30 per cent as much. The loss of juice in the frozen fruit is not due simply

to concentration by evaporation, but, at least in great part, to an actual disappearance of the juice with all its constituents as shown by the following analyses:

TABLE 2.—COMPOSITION OF JUICE

Sample	Total Solids	Total Sugars	Acid as Citric
1. Juice of unfrozen fruit, 1912–13	13.9%	11.3	1.42
2. Juice of frozen fruit, 1912–13	16.2	.....	2.00
3. Juice of frozen fruit, 1912–13	13.8	11.0	1.40
4. Juice of frozen fruit, 1912–13	13.6	.....	1.30
5. Juice of unfrozen fruit, 1912–13	13.0	.....	.90
6. Juice of unfrozen fruit, 1912–13	12.0	.....	.99

These data, showing that the concentration of the solids in the juice from the frozen and unfrozen oranges is about the same and the fact that there is a much greater quantity of juice in the unfrozen oranges, indicate a disappearance of both solids and liquid after freezing.

A comparison of samples 1 and 2 might indicate a slight concentration due to evaporation, but samples 1 and 3 show practically the same composition. On the whole, the composition of the juice seems to be little affected by the freezing of the oranges.

Orange juice according to these analyses, shows nearly three times the amount of acidity found in grape juice and five or six times the amount found in apple juice. The total solids are about two-thirds those of grape juice and a little less than those of apple juice.

Clearing.—The juice should be made permanently bright, so that it will have an attractive appearance in bottle. Fresh juice will not filter easily and is difficult to make bright by filtration until it has stood a certain length of time. The length of time necessary varies considerably, but, in all the tests made in the laboratory, twenty-four to seventy-two hours was the maximum variation. The following observations bring out the effect of preliminary defecation by standing and settling on the clearing of the juice by filtration.

TABLE 3.—EFFECT OF STANDING FOR VARIOUS TIMES BEFORE FILTERING

Sample	Observations
1. Fresh juice	Filters slowly and filtrate is cloudy.
2. Same juice after 18 hrs.	Filters slowly and filtrate is cloudy.
3. Same juice after 52 hrs.	Filters slowly but filtrate is clear.
4. Same juice after 76 hrs.	Filters easily and filtrate is clear.

Other samples of juice behaved similarly, except that in most cases the time necessary for defecation was less than the seventy-six hours noted in the table. One sample became jelly-like in a few hours after expressing it from the oranges, but two days later the

jelly-like material coagulated and settled out, carrying down all suspended matter, leaving a perfectly bright liquid above. Apparently a coagulating or clotting enzyme is active in bringing about the clearing of the juice. Further evidence for the existence of such an enzyme in orange juice is given by the fact that, if the juice is pasteurized, it will not clear, but will remain cloudy until filtered or clarified by other means. It is a property of all enzymes that they are destroyed by heat; therefore the fact that unpasteurized juice clears of its own accord and the pasteurized undefecated juice does not, indicates the presence of such an enzyme.

Several samples of the same juice were treated as follows:

1. Defecated 50 hours and then heated in bottles to 185° F.
2. Defecated 50 hours, egg albumen added at the rate of 5 oz. per 100 gallons, then heated in bottle to 185° F.
3. Defecated 50 hours, casein added at the rate of 5 oz. per 100 gallons, then heated in bottle to 185° F.
4. Not defecated; casein added at rate of 5 oz. per 100 gallons immediately after pressing and then heated in bottle to 185° F.
5. Not defecated; heated in bottle to 185° F. immediately after extraction from the fruit.

Seven months later, samples 1, 2 and 3 were bright, but 4 and 5 were cloudy. These tests demonstrate the utility of defecation in clearing the juice. (Compare especially tests 3 and 4.) They also indicate that finings are unnecessary for the clearing of the juice. (Compare test 1 with tests 2 and 3.)

Three other small lots of juice were treated in the following ways:

6. Same juice as No. 5, defecated seventy-six hours with sulfurous acid, filtered, pasteurized at 185° F. in bottle. This juice came from unfrozen oranges.
7. Juice from frozen oranges tested in same manner as No. 6.
8. Same juice as No. 7. Not treated with sulfurous acid. Filtered several times till bright and pasteurized twice at 185° F.

Seven months after pasteurization, samples 6, 7, 8 were all bright. No. 6 was of a slightly lighter shade than No. 7. No. 8 was dark brown in color. Samples 6 and 7 exhibited very little cooked flavor; No. 8, on the other hand, had enough of the cooked taste to make it considerably inferior to samples 6 and 7. Although not treated with sulfurous acid, sample 8 did not have a very pronounced bitter flavor, probably because it was sterilized so soon after extraction, thus not allowing time for the development of the bitter flavor.

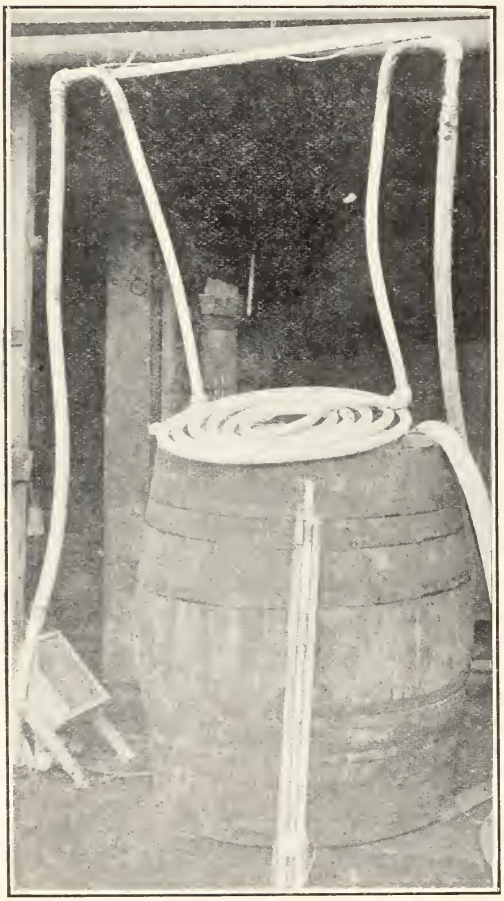
In the settling out process, or defecation of the juice, two serious difficulties are met with. The first is that the juice will start to ferment if allowed to stand long enough to defecate, unless treated in some way to delay fermentation. Secondly, a bitter taste develops in the untreated juice if it is long exposed to the air. Tests have shown that the addition of moderate amounts of sulfurous acid will prevent fermentation for the desired length of time and will also prevent the development of the bitter taste. Since sulfurous acid acts in the opposite manner to the oxygen of the air, it may be surmised that the development of the bitter flavor in orange juice is due to the oxidation of some tasteless constituent of the juice to a bitter form. An experiment indicated that the sulfurous acid must be added very soon after the oranges are crushed in order to check the bitter flavor, as in this particular test, a bitter taste was perceptible in one-half hour after the juice had been expressed. The amount of sulfurous acid necessary in any case will probably not exceed two or three ounces per 100 gallons of juice, or if reckoned in terms of the form in which it is most usually applied, not more than four to six ounces of potassium metabisulfite. The latter is most conveniently added as a water solution which is made up so that each gallon contains the amount of sulfite necessary for 200 gallons of the juice. For example, if it is desired to add eight ounces to each 200 gallons, a solution is made containing eight ounces of the metabisulfite per gallon of water.

After the addition of the potassium metabisulfite, the juice may be allowed to stand in convenient containers, until it has defecated long enough to permit rapid filtration. The amount of sulfites recommended are well below the limits allowed by law in various food products. It may also be stated that a great deal of the sulfurous acid disappears during subsequent treatment, so that the amount left in the juice is negligible.

Filtration.—After the juice has defecated a sufficient length of time, it may be filtered without difficulty to give a bright liquid. In this process, it will be necessary to draw off the clear liquid from the sediment in the defecating vessel. This juice can undoubtedly be filtered in a commercial way in any of the good filters that are on the market. A pulp filter would probably be the best for the defecated juice. The sediment from the defecating vessel may be thrown on bag filters and in this way brightened; it cannot be passed through the pulp filter (because of clogging) without a preliminary filtering through a bag filter.

Orange juice is much more easily filtered than grape or apple juice and gives on filtration a very brilliant liquid. This juice also differs from filtered fresh apple or grape must in that it remains bright after heating; fresh grape and apple juices may be filtered bright but will often not remain bright after heating.

Pasteurization.—The juice must be pasteurized after filtration to prevent fermentation. It may either be bottled before pasteurization or may be pasteurized and stored in barrels until it is convenient to bottle.



Discontinuous Pasteurizer

If the juice is stored in barrels the latter must be new or must have been used only for juice and kept sterile by burning sulfur tapes in them when empty. Before filling, the barrels should be thoroughly steamed to sterilize the inner surface. Several forms of pasteurizers may be used in the heating of the juice to the desired temperature. One of the simplest types may be made by placing a non-corrodable metal coil in a wooden container of convenient size. Juice may be placed in this container and steam passed through the coil. The coil should be kept in motion during the heating in order to avoid scorching the juice. A tin or aluminum coil will not be attacked by the orange juice. Double jacketed aluminum kettles are used with success in the pasteurization of grape juice and apple cider, and would no doubt give satisfaction in the sterilization of orange juice. Steam is passed between the walls of the kettle to heat the juice.

Both of the above heaters are discontinuous in their action. Where a continuous flow of sterilized juice is desired, a continuous pasteurizer may be constructed by placing a tin pipe inside of an iron pipe. Steam may be passed through the outer pipe and juice through the inner tin pipe. By varying the steam pressure and the flow of juice, the desired temperature may be attained. Continuous pasteurizers suitable for this purpose are obtainable.

In any case, the juice should reach a temperature of 185° F. It should then be run into clean barrels. The barrels should be bunged immediately with a new bung covered with a clean cloth. The barrel should then be rolled on its side to sterilize the bung with the hot juice. The flavor of orange juice seems less easily injured by overheating than that of grape or apple juice.

During the first few weeks of storage, the barrels must be carefully watched in order that those which start to ferment may be detected in time to save them. With careful work few, if any, should ferment.

Pasteurization in Bottles.—Whether the juice is bottled immediately after filtering or stored first, for a time, in barrels, it must receive a final pasteurization after bottling. The bottles and corks and caps that are used must be clean. Capping is preferable to corking, because it gives less trouble in handling and gives a neater appearance to the bottle. There are two types of caps, the Crown cap and the Goldy cap or stopper. The Crown cap is the ordinary beer bottle or soda water bottle cap, while the Goldy stopper is the aluminum cap seen on grape juice and pineapple juice bottles. The latter type is more expensive, but is preferable. The bottles must be sterilized immediately after filling and capping. A convenient form of pasteurizer may be used by placing a false bottom in a rectangular wooden tank. Under the false bottom is placed a steam coil. The bottles are placed on the false bottom, water is admitted so that its level is about three-fourths the height of the bottles. The pasteurizer must be covered in order that the caps and tops of the bottles will be heated by the escaping steam. One bottle may be left uncapped. A thermometer is placed in this bottle and the rise in temperature noted. The liquid in the bottles must reach a temperature of 180° F.

The bottles may then be removed and allowed to cool. They should be stored until it is seen whether the pasteurization has been successful and whether any of the bottles develop cloudiness. Three weeks or a month will probably be sufficient in most cases. If the juice remains clear, it may be put on the market. In laboratory tests the juice pasteurized in bottles developed a slight sediment after three months, but so small in volume as to be scarcely noticeable.

To some, the unclarified juice might be preferable to the clear. If such a juice is to be produced, no filtration is necessary and the juice can be placed in bottles imediately and sterilized. Its appearance would probably not be pleasing, hence would have to be disguised in dark bottles.

Summary.—It is recommended that the freshly expressed juice be allowed to defecate until it becomes fairly clear. To prevent fermentation during this period and to check the development of a bitter flavor, a moderate amount of sulfurous acid should be added to the juice, immediately after crushing. Potassium metabisulfite is a convenient form in which to add the sulfurous acid. The defecated juice should be filtered. It may then be bottled immediately and pasteurized, or may be pasteurized in barrels and kept until it is desired to bottle it. The bottled juice should be sterilized at 180 to 185 degrees Fahrenheit to prevent fermentation and mold growth, especially the latter.

ORANGE VINEGAR

The samples or orange juice thus far examined have averaged by chemical test about 11 per cent actual total sugars. This would on fermentation give about 5.5 per cent alcohol if the fermentation were carefully conducted. Theoretically, 1 per cent of alcohol will, after conversion into acetic acid, give 1.2 per cent acetic acid. Actually, 1 per cent of alcohol gives approximately 1 per cent of acetic acid. Therefore orange juice of the above composition should give vinegar containing considerably over the minimum legal limit of 4 per cent acetic acid.

TABLE 4.—VARIATION IN COMPOSITION OF ORANGE JUICE

Sample	Balling Total Solids	Total Acid	Sugar
Frozen Valencias, Riverside, 1912–13	12.2	1.5	.....
Frozen Valencias, Riverside, 1912–13	13.8	1.4	11.0
Frozen Navels, Riverside, 1912–13	16.1	2.2	.....
Unfrozen Navels, Los Angeles, 1912–13	13.0	.90	.....
Unfrozen Navels, Los Angeles, 1912–13	13.9	1.42	11.3
Unfrozen Valencias, Tulare, 1913–14	13.5	1.5	.....
Unfrozen Navels, Tulare, 1913–14	11.5	1.3	.....
Unfrozen Navels, Redlands, 1913–14	12.1	.9	.....

Crushing, Pressing and Defecation.—The juice may be extracted in the same way as in the production of unfermented orange juice. For the same reasons as in the case of the unfermented juice, the juice to be used for vinegar should be treated with potassium metabisulfite and allowed to defecate before fermentation. Four to six ounces of

the sulfite dissolved in water will be sufficient for each 100 gallons of juice. The clear juice may be drawn off after defecation and the mud may be filtered through bag filters. It is necessary to remove all of the pulp because it will rise during yeast fermentation and form a cap on which mold growth is very apt to take place; furthermore the pulp may give trouble in the acetic acid fermentation that follows the alcoholic fermentation.

Alcoholic Fermentation.—The production of vinegar from any sugary liquid depends on two separate and distinct fermentations. The first of these consists in the transformation of the sugar into alcohol and carbon dioxide and is brought about by the activity of yeasts. The second is the change of the alcohol into acetic acid. This latter change is carried on by vinegar bacteria. For the successful production of vinegar, conditions should be favorable to the activity of a desirable type of yeast during the alcoholic fermentation and unfavorable to all other classes of yeasts. During the acetic fermentation the activities of the vinegar bacteria should be favored as much as possible.

Orange juice left to itself develops many different types of yeasts and molds, and undergoes a fermentation that results in a low yield of alcohol and a fermented juice of poor flavor. Hence it is desirable to add pure yeast to the defecated juice in order that a good fermentation will result. Such a yeast is distributed from the Enology Laboratory of the University and may be had on application. Full directions for its use and propagation are sent with the yeast.

If grown in well defecated and sulfited juice, the yeast will remain sufficiently pure, throughout the season, if used according to directions accompanying the sample sent from the Enology Laboratory. The following figures were obtained in laboratory fermentations of orange juice.

TABLE 5.—YIELDS OF ALCOHOL FROM ORANGE JUICE

Sample	Balling of Juice	Possible Alcohol	Alcohol obtained	Loss due to Natural Yeast
1. Pure Yeast fermentation	11.2%	4.25%	4.25%	.....
2. Natural fermentation	12.8	5.18	4.5	.68%

Sample No. 1 was fermented with pure yeast; No. 2 was allowed to ferment naturally. Although the Balling was 1.6% higher in the latter case, the yield of alcohol was only .3% higher, indicating a greater efficiency in the pure yeast fermentation. It may be stated that the natural fermentation in No. 2 was carried on largely by undesirable types of yeast. This also happened in most cases where the juice was allowed to ferment spontaneously. In Sample No. 2, a heavy growth of film forming yeast developed, giving a disagreeable flavor

as well as causing the liquid to clear very slowly after fermentation. On the other hand, the juice fermented with the pure yeast had a clean flavor and was easily cleared.

Vinegar Fermentation.—The transformation of the alcohol of the fermented orange juice into acetic acid takes place only with an abundant supply of air because it consists in the addition of the oxygen of the air to the alcohol, in this way changing it into acetic acid or vinegar. However, if one should attempt to make vinegar by simply exposing freshly fermented orange juice to the air, vinegar fermentation would not ensue. In its place, there would be a vigorous growth of wine flowers which would destroy the alcohol without the formation of acetic acid. Therefore something must be done to encourage the growth of the vinegar bacteria and discourage the development of the wine flowers. By adding a considerable amount of strong vinegar to the orange wine, the per cent of acetic acid is raised sufficiently to give the vinegar bacteria a good advantage over the wine flowers. The addition of vinegar also inoculates the liquid with a large number of vinegar bacteria and will give a rapid start to the vinegar fermentation. The first lot of vinegar could be started in this way with strong cider or wine vinegar free from vinegar eels; vinegar equal to about one-fourth of the volume of the liquid to be acetified should be added to the fermented juice. When this has been changed to vinegar, three fourths of the vinegar may be drawn off and replaced with new alcoholic liquid. The one-fourth left from the previous lot serves to start the next vinegar fermentation and prevents the growth of wine flowers.

A convenient form of vinegar barrel may be made by filling an ordinary fifty gallon barrel about three-fourths full of fermented juice and then boring a hole in each end a few inches above the level of the liquid. The holes must be covered with several layers of mosquito netting or a heavily tin plated wire gauze to prevent the access of vinegar flies. Bulletin 227 of the University of California Experiment Station gives a description and drawing of the construction of such a barrel. On a large scale, a vinegar generator could probably be used, though it is problematical whether a generator would give a vinegar of sufficiently high acid content because of the greater waste of alcohol in the generators as compared to the slow process. The construction of a vinegar generator is described in Bulletin 227.

The progress of the vinegar fermentation should be followed by the use of a Leo or a Twitchell acetometer so that the point at which the vinegar fermentation is complete may be noted. This will be when there is no further increase in the acidity of the vinegar. The use of

the acetometer is explained in Bulletin 227, which may be had on application to the Director, Agricultural Experiment Station, Berkeley.

Table 6 gives the results obtained at the laboratory from three samples of orange juice by following the method described above. Another sample was fermented and allowed to stand on the pulp to note whether vinegar fermentation took place. This material was attacked by green mold and finally by putrefactive bacteria. The juice turned to an evil smelling liquid devoid of acid or alcohol.

Another large sample was fermented carefully and drawn off the yeast sediment. It was then allowed to stand exposed to the air. Vinegar fermentation did not ensue but the juice became covered with a heavy growth of wine flowers. It finally became very flat tasting and totally unfit for vinegar making.

The results obtained from the juice made into vinegar by yeast fermentation followed by vinegar fermentation brought about by the addition of strong vinegar equal in volume to one-fourth the volume of the fermented juice, are given in the following table:

Table 6.—Yields of Acetic Acid in Orange Vinegar from Frozen Oranges

Sample	Balling per cent of Original Juice	Total Acid in Vinegar	Volatile Acid (Vinegar Acid) in Vinegar	Alcohol in Vinegar
1. 717*d*	12.2	6.44	5.18	Trace
2. 717*e*	12.5	4.36	3.36	Trace
3. 717*f*	12.5	4.80	3.60	Trace

The juice for sample 1 was defecated with the help of sulfurous acid and the clear juice was fermented with pure yeast. The clear wine was allowed to stand several days after alcoholic fermentation and was then drawn off the yeast and fermented into vinegar by use of a vinegar starter. The juice for samples 2 and 3 was made from the same oranges as that of sample 1. This juice was divided into two equal portions. Neither received any sulfurous acid or defecation and both were fermented with pure yeast. The wine of sample 2 was drawn off the yeast and acetic fermentation carried out as in sample 1. Sample 3 was treated in the same manner as sample 2 except that the wine was not drawn off the yeast and sediment before acetic fermentation.

The use of sulfurous acid and defecation seemed to favor a better vinegar fermentation, or at least resulted in a higher yield of acetic acid than where no sulfurous acid or defecation was used. The presence of the yeast and sediment during acetic fermentation apparently had little or no effect on the yield of acetic acid where a vinegar starter was used. It is probable, however, that the sediment

would injure the flavor if left during acetic fermentation and should therefore be removed by drawing the wine from it.

The acetic acid in sample 1 was well above the legal pure food standard of four per cent while samples 2 and 3 were below this standard. If the total acid, instead of acetic acid, is taken as the measure of the strength of the vinegar, then all three samples satisfy the pure food requirements. Commercially, a vinegar of 4% total acid is called a "40 grain" vinegar which is the legal standard.

Most of the orange flavor was lost during vinegar fermentation and the flavor of the finished vinegars was not so agreeable as that of apple or wine vinegar. The inclusion of a little of the orange oil from the skins during extraction of the juice might improve the flavor, or at least increase the orange flavor.

Clearing the Vinegar.—All of the vinegar samples made in the laboratory were easily filtered bright. The addition of a small amount of infusorial earth to the first vinegar which was passed through the filter aided a great deal in giving a clear filtrate. For the filtration of the vinegar on a commercial scale, a pulp filter could be used. Such a filter would have to be heavily tinned to prevent solvent action of the vinegar on the metal parts of the filter.

Wine and cider vinegar may be clarified by the addition of isinglass dissolved in a small amount of the vinegar. There is little doubt that orange vinegar would yield to the same treatment, although tests were not made on this point.

Summary.—Orange vinegar may be made if the following points are observed. The fresh juice should be treated with four to six ounces of potassium metabisulfite per 100 gallons of juice and the juice allowed to stand and deposit its gross sediment for twenty-four hours or more. The clear juice should be drawn off and fermented with pure yeast. Immediately after alcoholic fermentation the fermented juice should be drawn off the yeast and stored in well-filled, closed barrels or tanks until it is convenient to turn the juice into vinegar. Strong vinegar equal in amount to about one-fourth the volume of the fermented juice should be added to the orange wine to prevent the growth of wine flowers and promote the development of the vinegar fermentation. The vinegar fermentation must take place in containers that allow a good surface of the vinegar to be exposed to the air. The vinegar may be cleared by filtering.

ORANGE WINE

Beverages are met with at present bearing the name of orange wines. All samples so far examined at the laboratory have proved to be sweet liquors with medium to high alcoholic content and with a

flavor of orange extract or orange oil. They gave evidence of having been made from sherry, sweetened by the addition of sugar and flavored by the addition of orange extract or oil in some cases, and in others of having been made from poorly fermented orange juice fortified by the addition of alcohol and sweetened by large additions of sugar. Analyses of such "wines" are given in the following table:

TABLE 7.—ANALYSES OF "ORANGE WINES"

Sample	Alcohol	Total Acid	Volatile Acid	Total Sugar
1	9.6%	.....	.47%	21.6%
2	9.6	.....	.26	18.2
3	18.0	.....	.08	17.6

Sample 3 was evidently a sherry flavored with orange oil or extract and sweetened. Numbers 1 and 2 may have been partially fermented orange juice that had started to turn to vinegar and had been then fortified by the addition of alcohol or brandy and sweetened by the addition of sugar or syrup. These are all "liqueurs" of bad quality and mis-labeled, as their composition and flavor show that they have no right to the title "Orange Wine."

TABLE 8.—ANALYSES OF ORANGE WINES MADE IN THE LABORATORY

Sample	Alcohol	Total Acid
1	4.25%	1.5%
2	4.5	1.52

Neither of these wines gave any perceptible taste of sugar. Both were very low in alcohol as compared with the artificial orange liqueurs cited in Table 5. The acid in the true orange wines is very much higher than that in the artificial product. Some of the wines* were made in the laboratory by treating the fresh juice with potassium metabisulfite at the rate of four to six ounces per 100 gallons and allowing the juice to settle until clear. Pure yeast was added to the clear juice after drawing it off the sediment. Another lot of the juice was allowed to ferment naturally. Both lots of wine were filtered after fermentation. Neither gave any trouble in filtering and both gave a brilliantly clear wine.

Most of the juice was pasteurized at 150° F. after fermentation and filtration into small bottles. The pasteurization did not affect the brightness of the wines, but did give a little cooked flavor to the sample that was not treated with potassium metabisulfite. The sulfited wine did not develop the cooked flavor to any appreciable extent. The flavor of the wine made by the use of defecation and pure yeast was superior to that of the wine made by natural fermentation. The

* For a fuller account of the methods of wine-making, see Bulletin 213, "The Principles of Wine-making," a copy of which can be obtained on request from the Agricultural Experiment Station at Berkeley.

naturally fermented wine was of a little darker color than the wine made with the sulfurous acid and pure yeast.

A small sample of the fermented juice was left unpasteurized in a well-filled, tightly corked bottle at the prevailing room temperature of 22° C. (or 72° F.). After three months' storage, it was still in the same condition in which it was placed in the bottle, indicating that the wine may be kept without pasteurization, provided it is stored in well-filled packages. Two samples of the unpasteurized wine left in partially filled bottles developed penicillum mold. Where it is to be subjected to high temperatures, it should be pasteurized, because it does not contain sufficient alcohol to protect it against spoiling by bacterial fermentation. A pasteurization temperature of 140° to 150° F. would probably be sufficient.

Sparkling Wines.—The filtered wine may be made into sparkling wine as follows, after the first fermentation is over. To the filtered wine 1.5 per cent cane sugar previously made into a thick syrup and boiled with a little citric acid should be added to the wine. This would be about 1.8 ounces of sugar per gallon of wine. To this, a little champagne yeast may be added and the wine bottled in champagne bottles. The bottles should be corked with champagne corks and left in a warm place for a few days until fermentation starts in the bottles. The corks must fit very tightly and must be well tied down. During the first few weeks, the bottles should be turned often to prevent the yeast from sticking to the sides of the bottles. They may then be placed in a cool place until fermentation in the bottle is complete. They should then be placed with the cork downward for several months. The yeast sediment will settle out on the cork. The bottle may then be held at a slanting position and the cork released by cutting the string that holds it. It will then be shot out of the bottle by the gas pressure in the bottle and carry the yeast sediment with it. The cork must then be replaced by a new cork, immediately, before the gas escapes or before too much of the wine is lost by the escape of the gas.

A sparkling orange wine made in the laboratory, but not relieved of its yeast sediment as described above, made a pleasing drink. It was preferable to the still wine made from the same juice.

Summary.—Orange wine may be made by defecating the fresh juice after the addition of moderate amounts of potassium metabisulfite to prevent fermentation for a short time, fermenting the clear juice with pure yeast, and filtering the finished wine to clear it. This cleared wine may be turned into sparkling orange wine by the addition of a small amount of sugar and by subsequent fermentation in bottles.